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Takeuchi et al.

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(45) **Date of Patent: Oct. 6, 2015**

(54) **LIQUID EJECTION HEAD BODY AND METHOD OF MANUFACTURING THE SAME**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(30) **Foreign Application Priority Data**

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B41J 2/14 (2006.01)
B41J 2/16 (2006.01)

(52) **U.S. Cl.**

CPC ***B41J 2/1433*** (2013.01); ***B41J 2/14072*** (2013.01); ***B41J 2/1603*** (2013.01); ***B41J 2/1626*** (2013.01); ***B41J 2/1628*** (2013.01); ***B41J 2/1629*** (2013.01); ***B41J 2/1631*** (2013.01); ***B41J 2/1634*** (2013.01); ***B41J 2/1642*** (2013.01); ***B41J 2/1645*** (2013.01); *B41J 2002/14387* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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Primary Examiner — Erica Lin

(74) *Attorney, Agent, or Firm* — Fitzpatrick, Cella, Harper & Scinto

(57) **ABSTRACT**

A liquid ejection head body includes a substrate and a channel forming member arranged on the substrate. The channel forming member has a liquid ejection port for ejecting liquid and a liquid channel communicating with the liquid ejection port, while the substrate has an ejection energy generating element for generating energy for ejecting liquid at a first surface side and a liquid supply port for supplying liquid to the liquid channel in the inside. A conductive layer for electrically connecting the first surface side and a second surface side disposed opposite to the first surface side is arranged along the lateral surface of the liquid supply port.

20 Claims, 18 Drawing Sheets

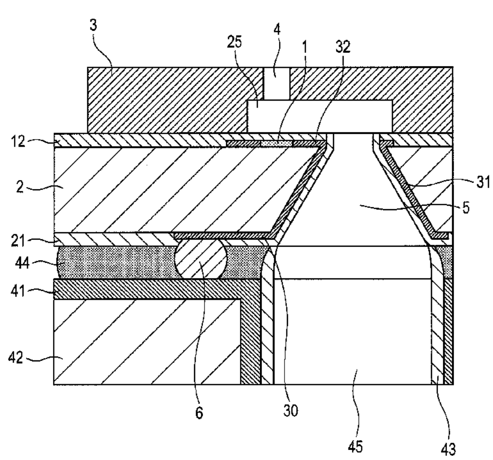

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FIG. 1

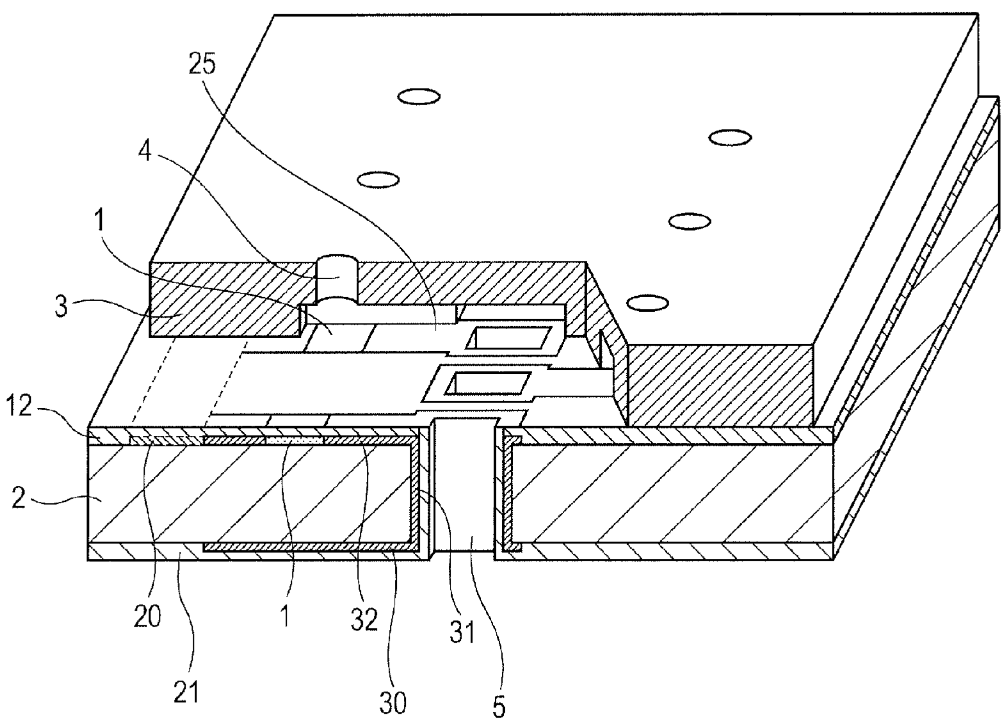


FIG. 2

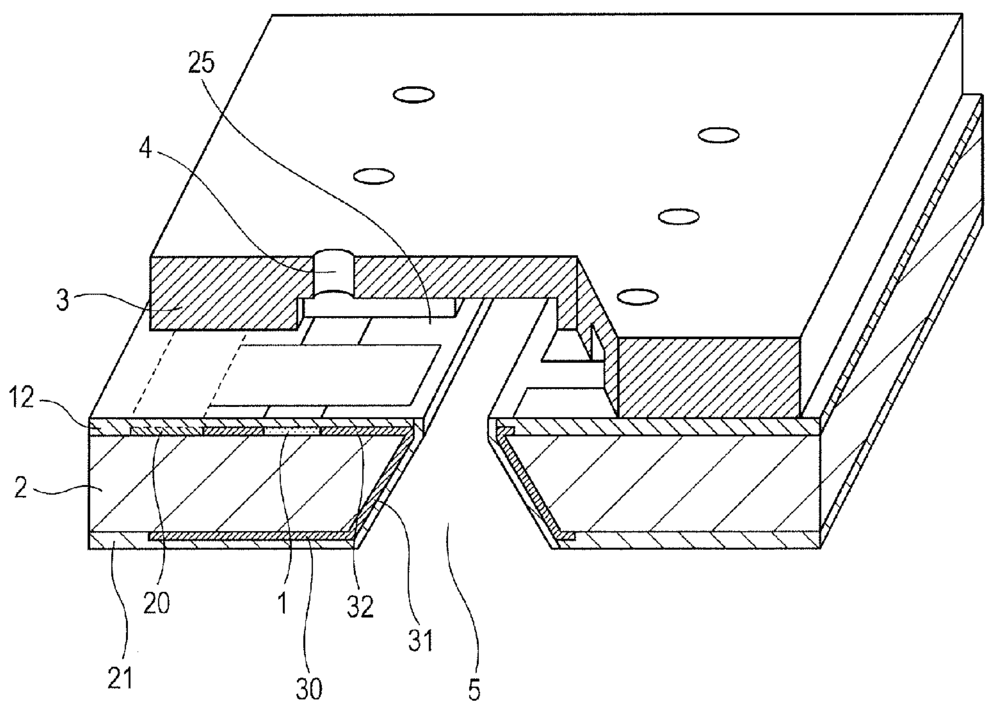


FIG. 3

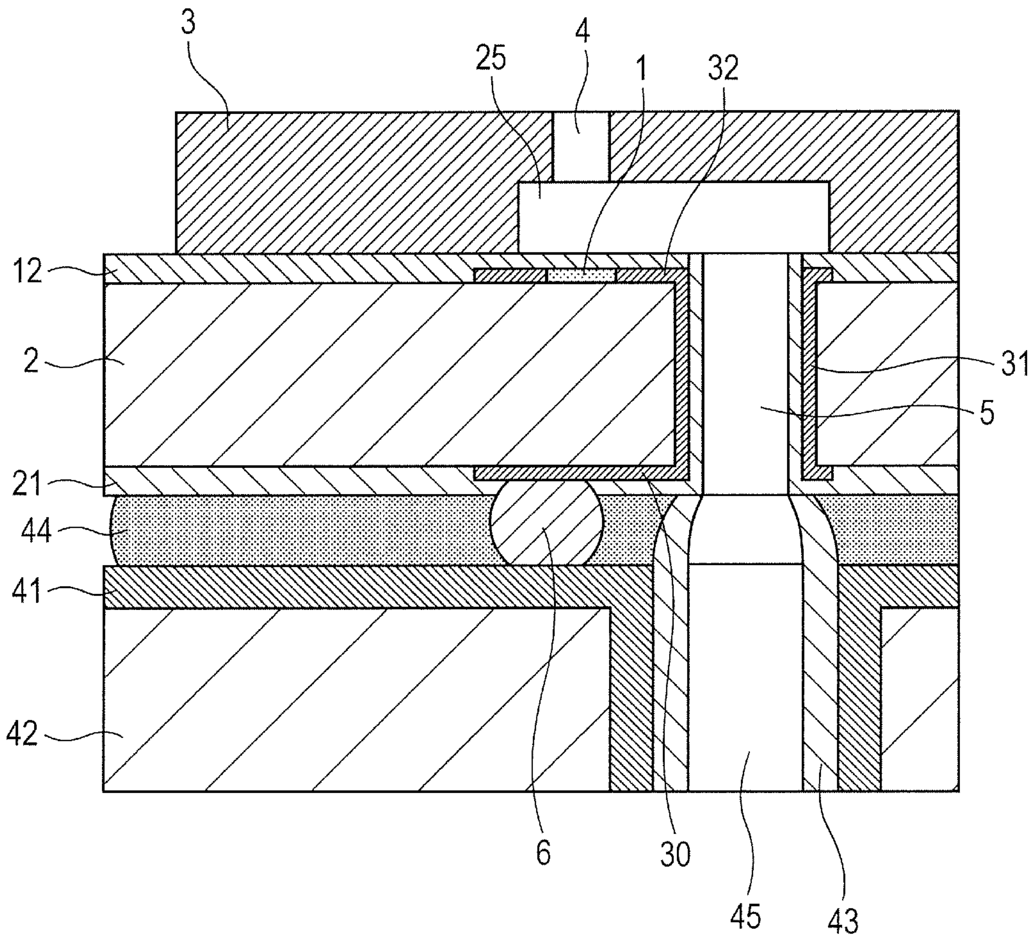


FIG. 4

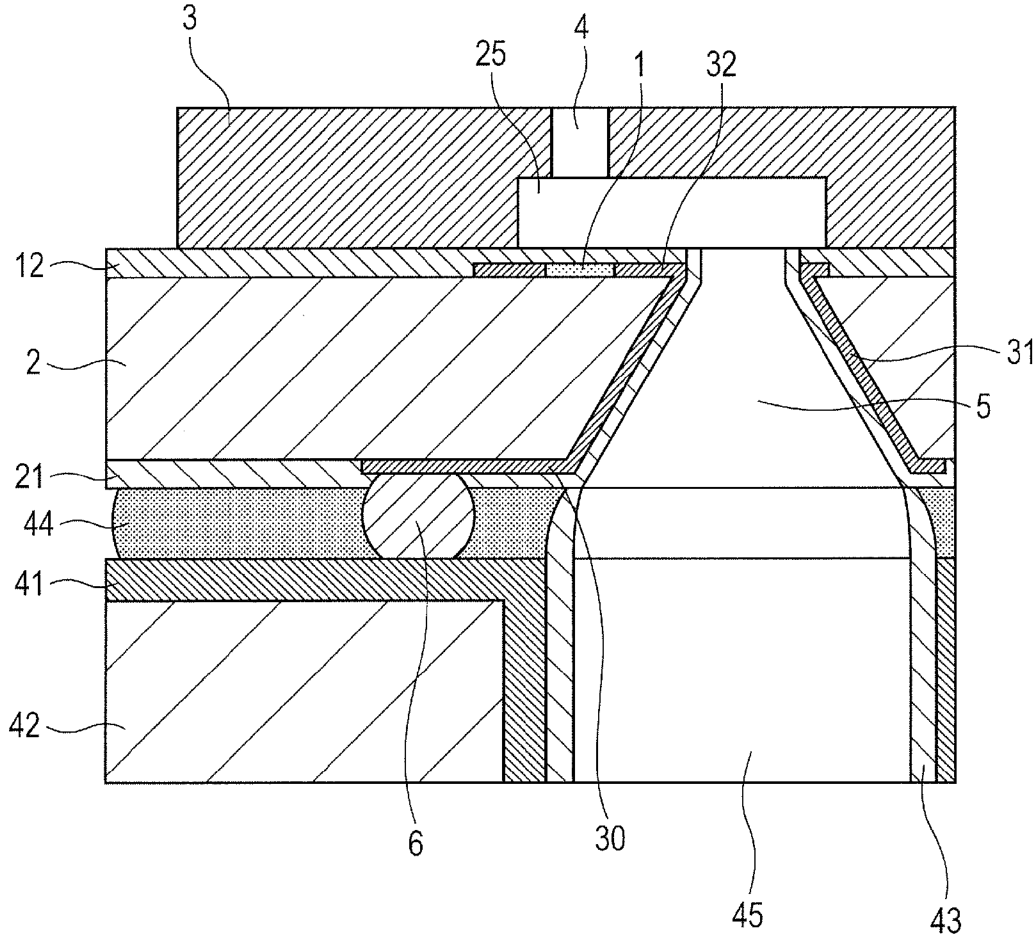


FIG. 5

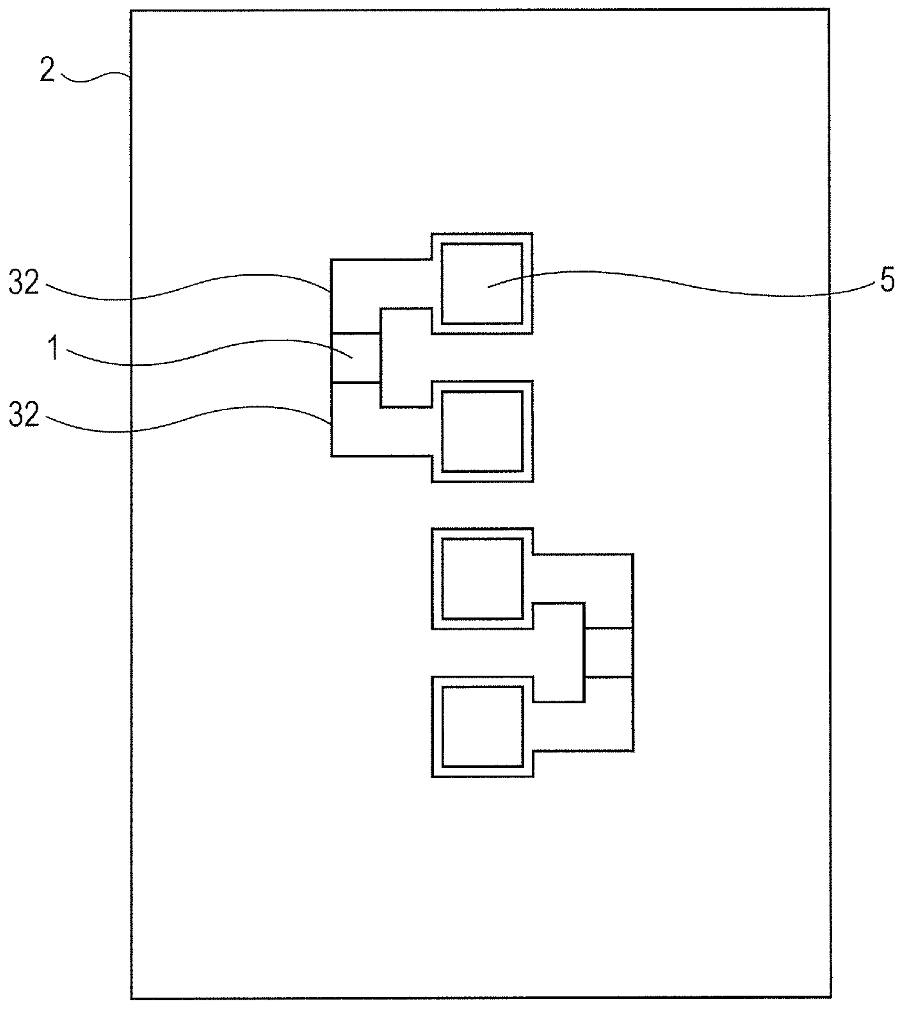


FIG. 6

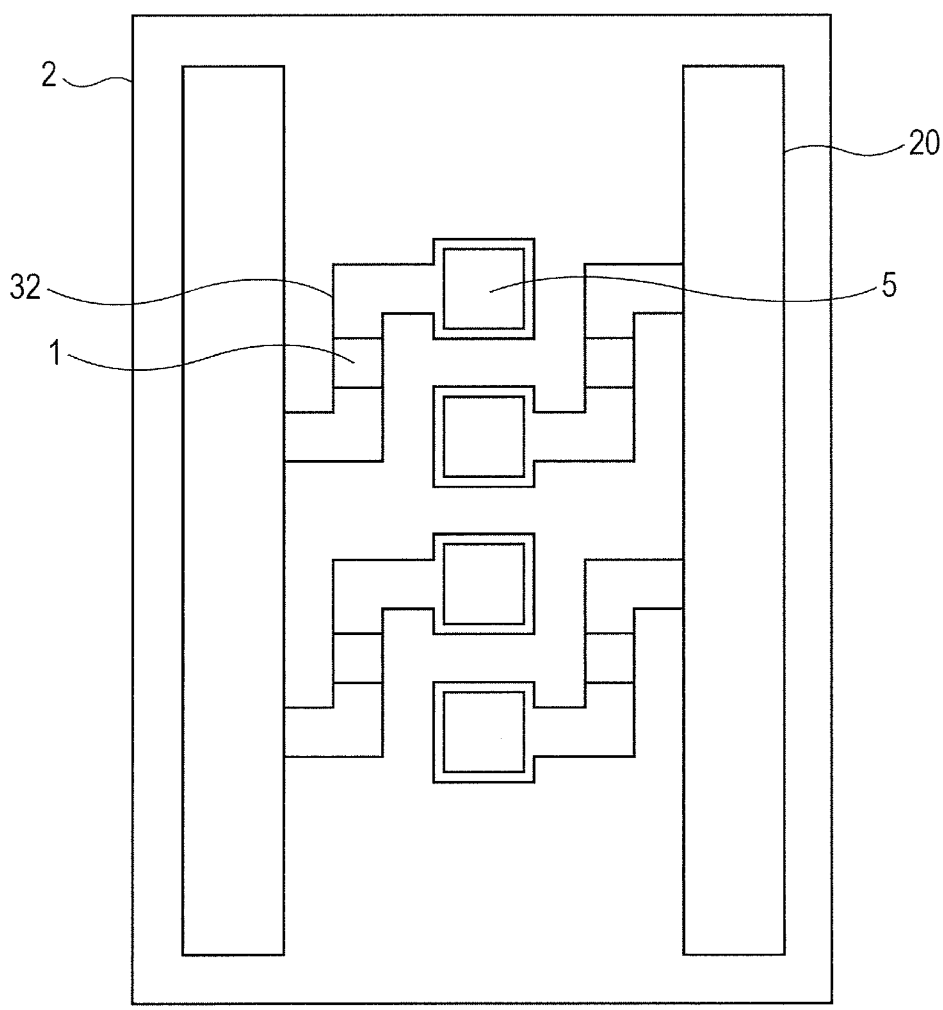


FIG. 7

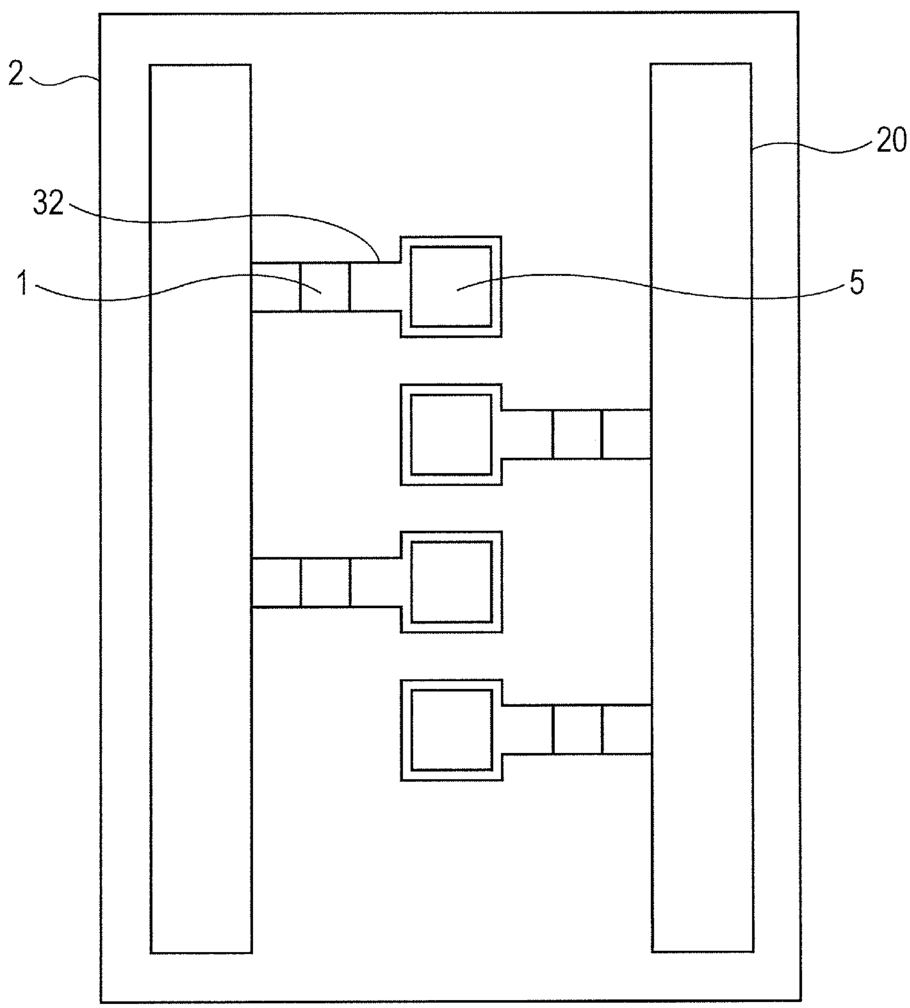


FIG. 8

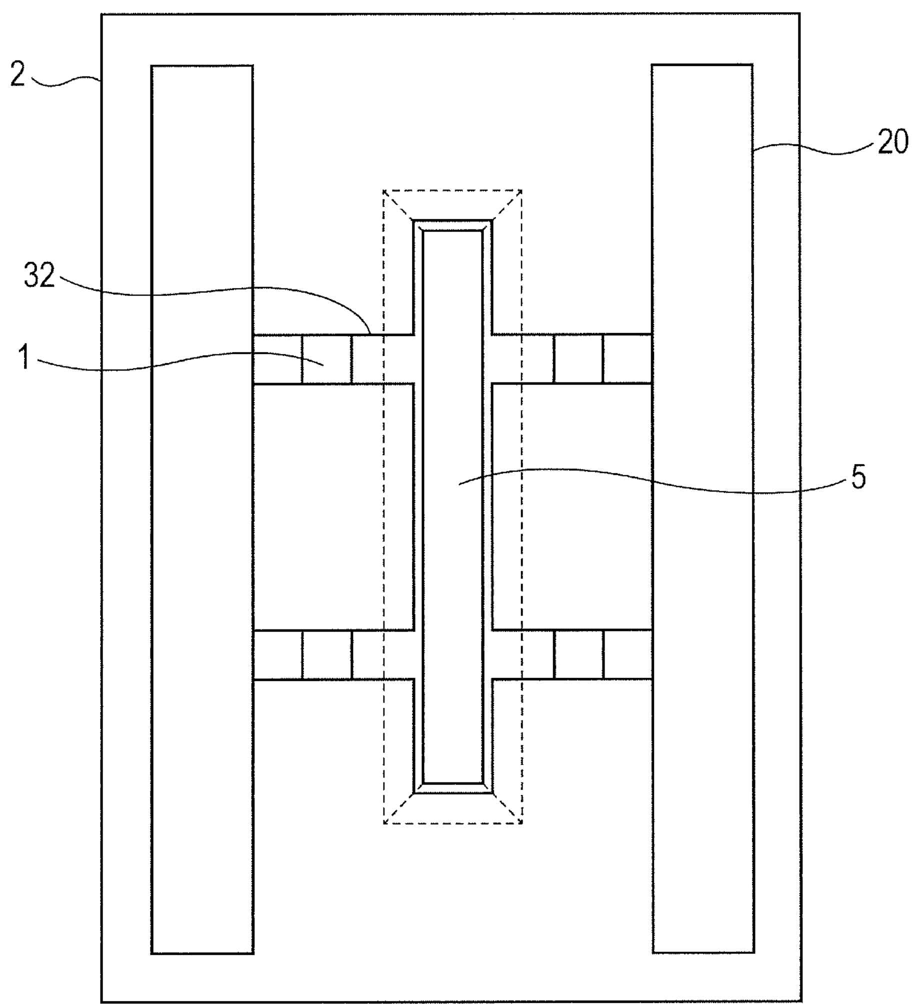


FIG. 9

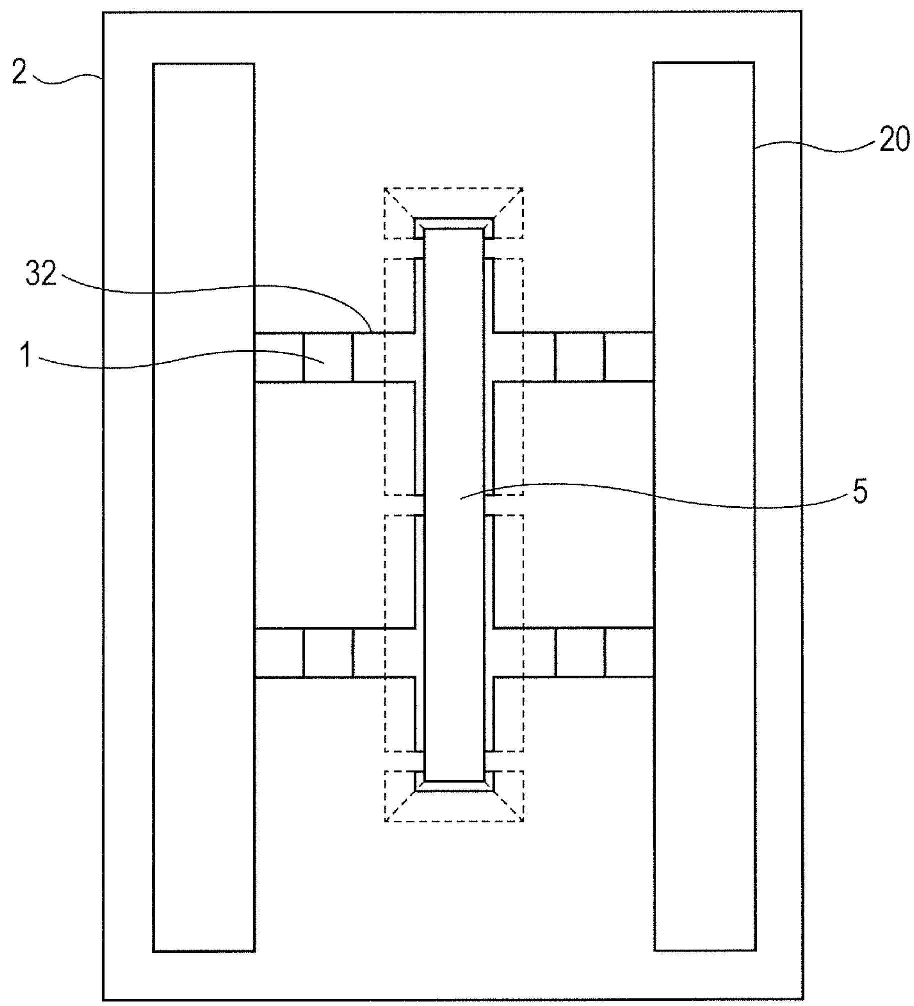


FIG. 10

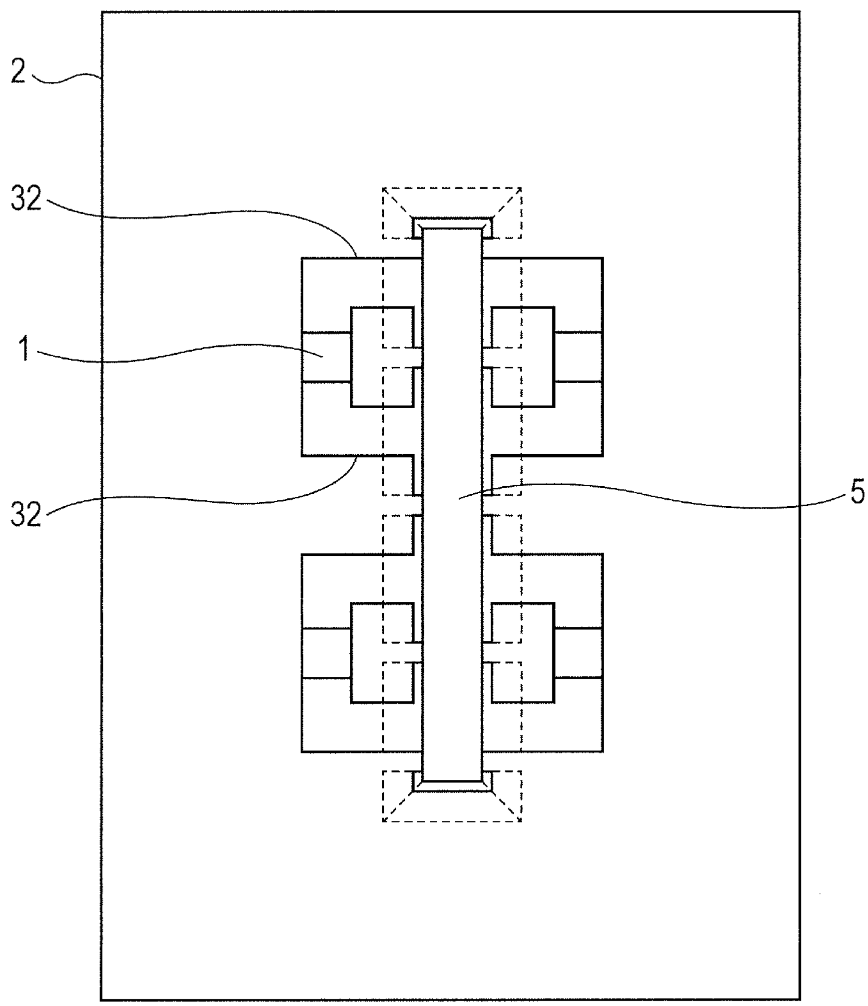


FIG. 11

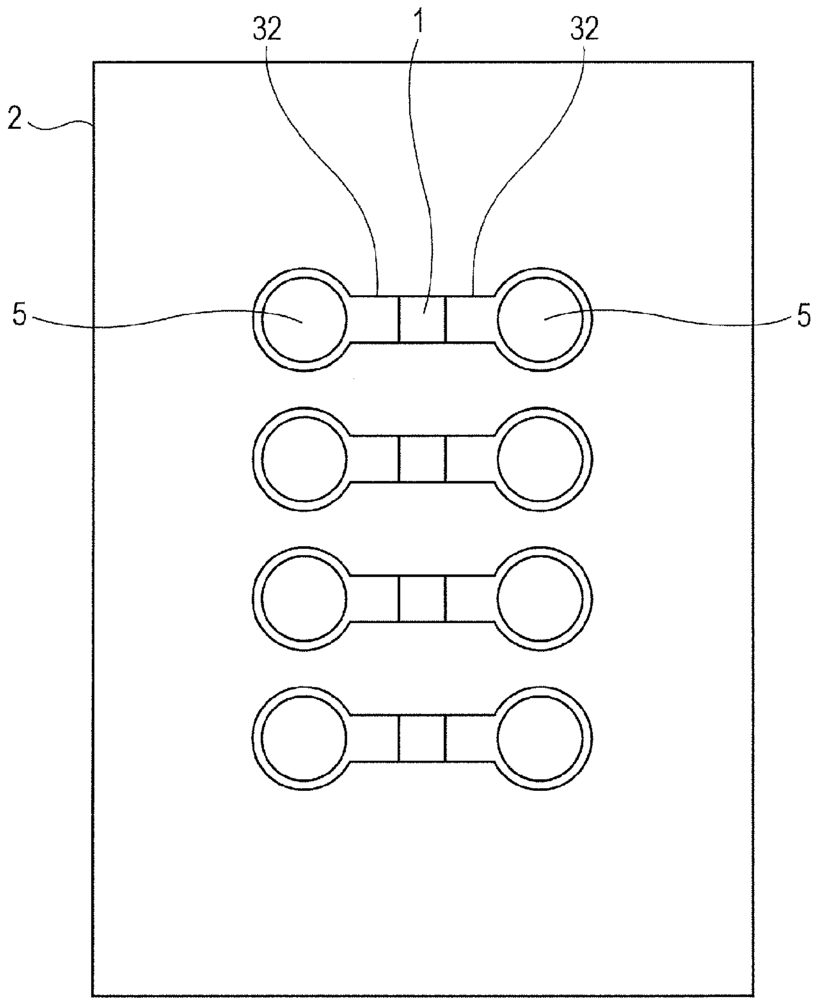


FIG. 12A

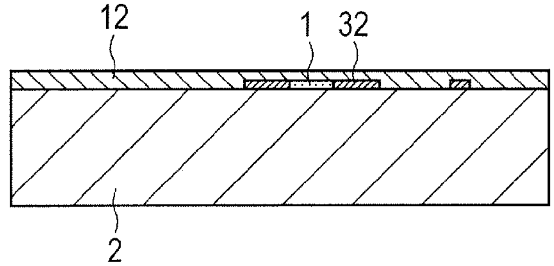


FIG. 12B

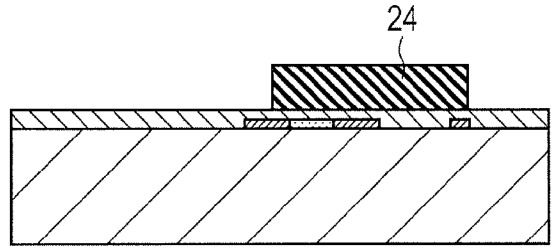


FIG. 12C

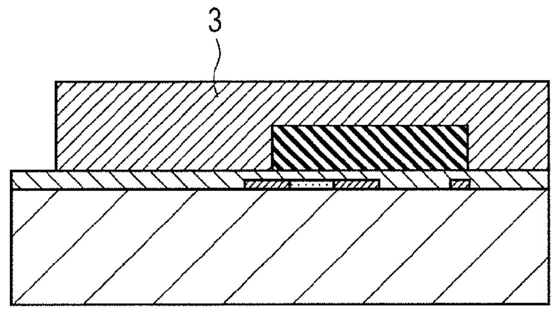


FIG. 12D

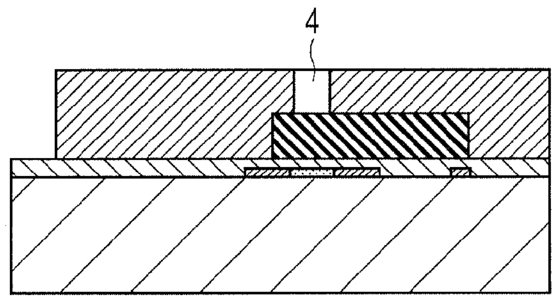


FIG. 12E

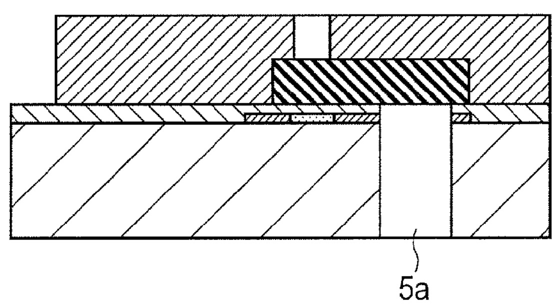


FIG. 12F

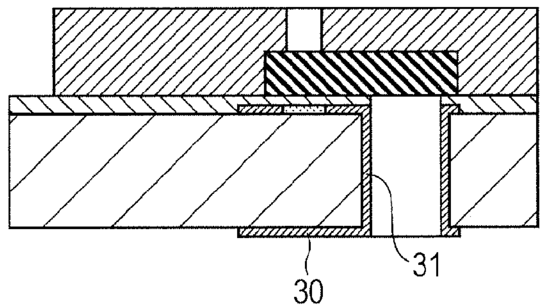


FIG. 12G

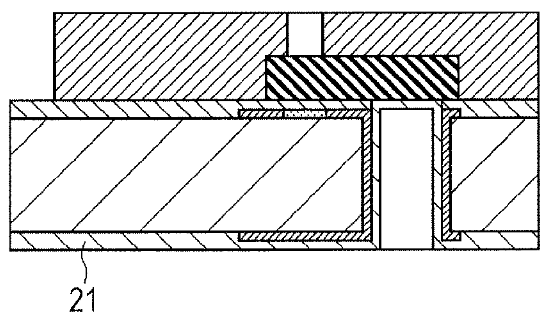


FIG. 12H

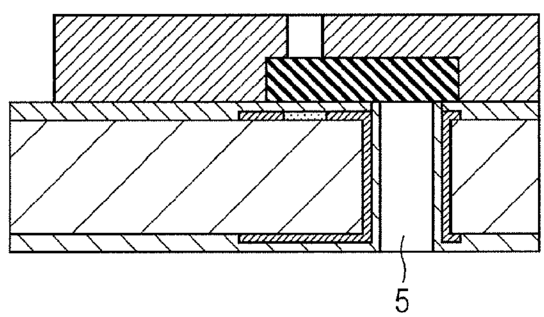


FIG. 12I

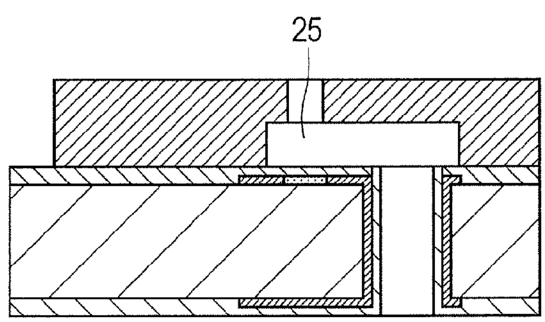


FIG. 13A

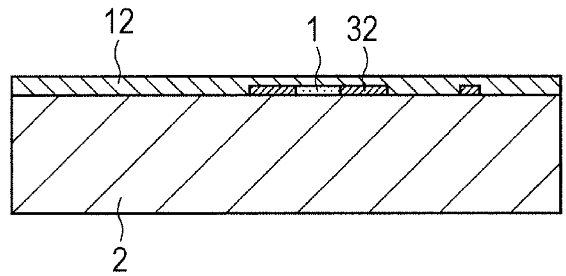


FIG. 13B

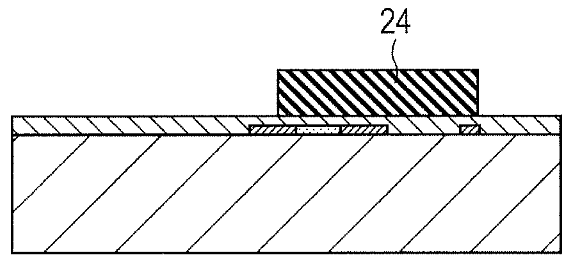


FIG. 13C

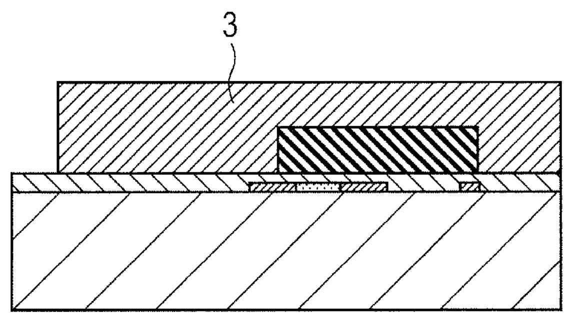


FIG. 13D

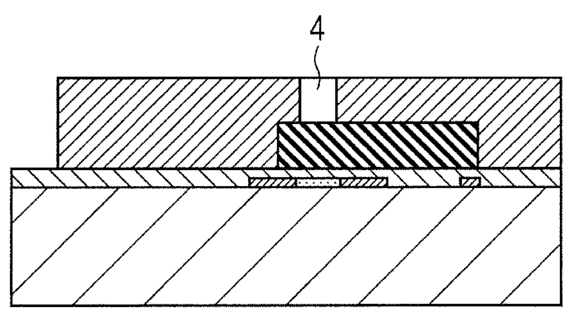


FIG. 13E

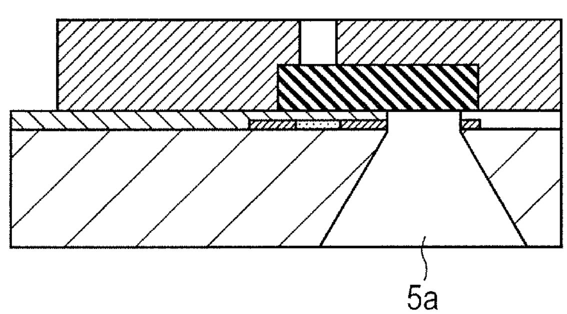


FIG. 13F

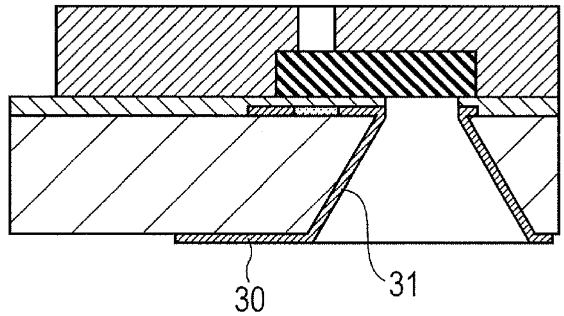


FIG. 13G

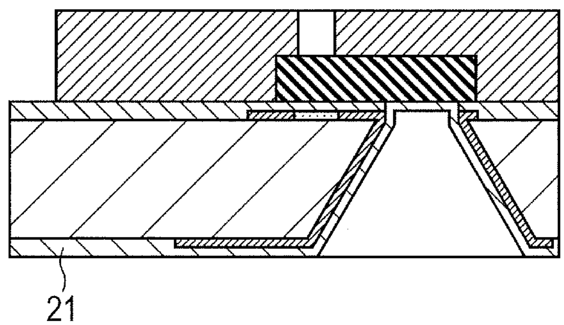


FIG. 13H

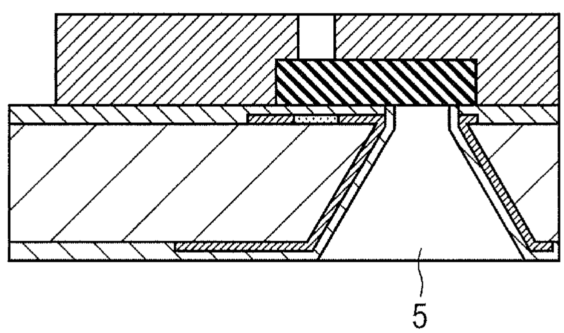


FIG. 13I

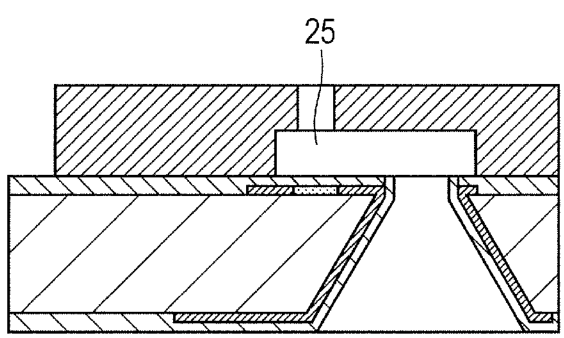


FIG. 14A

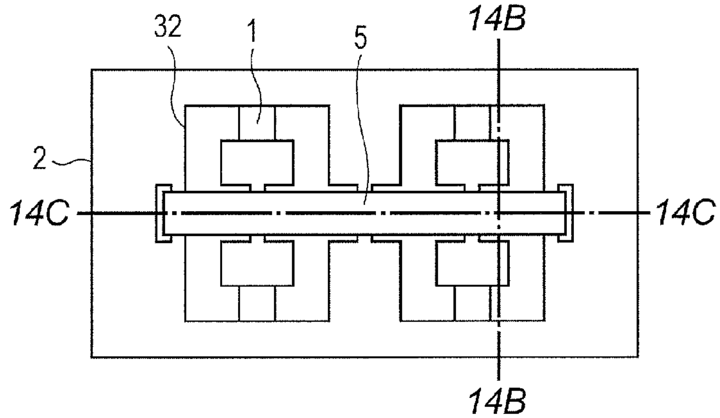


FIG. 14B

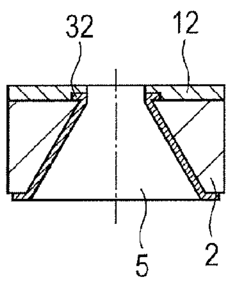


FIG. 14C

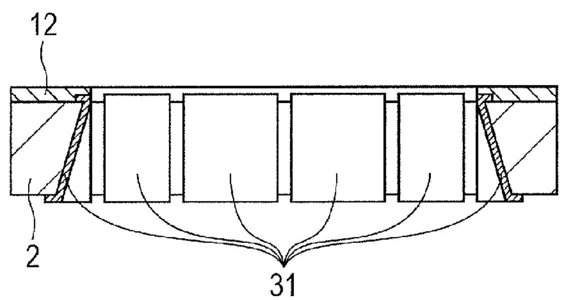


FIG. 14D

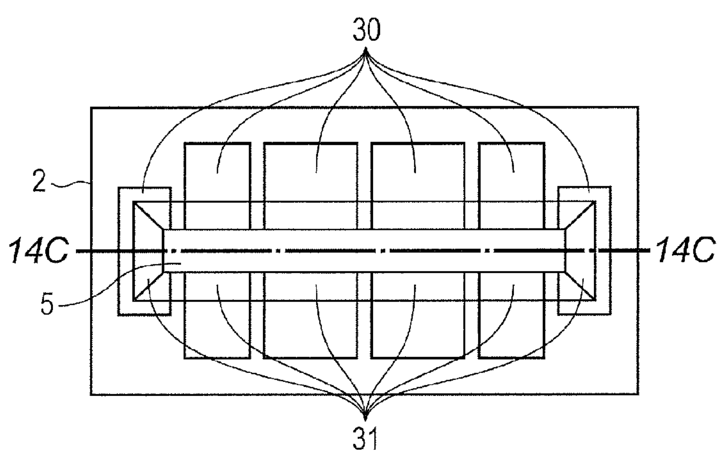


FIG. 15A

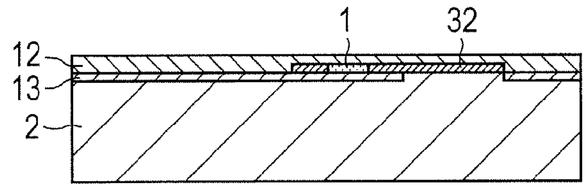


FIG. 15B

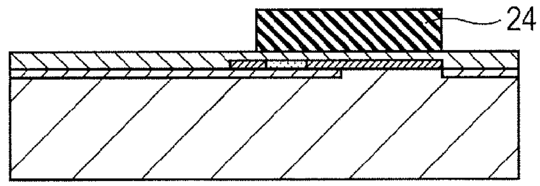


FIG. 15C

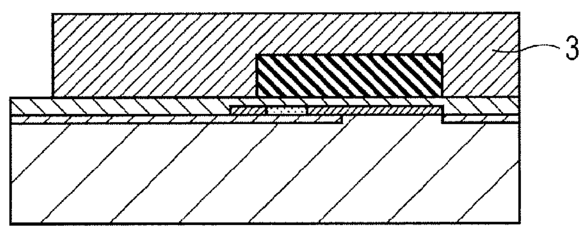


FIG. 15D

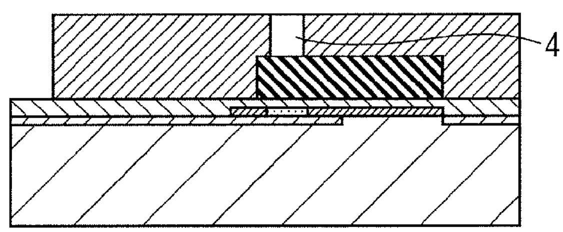


FIG. 15E

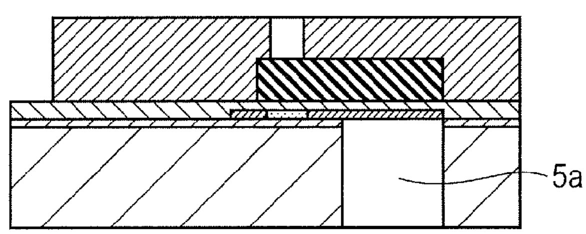


FIG. 15F

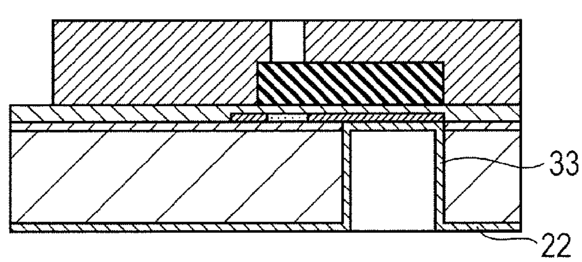


FIG. 15G

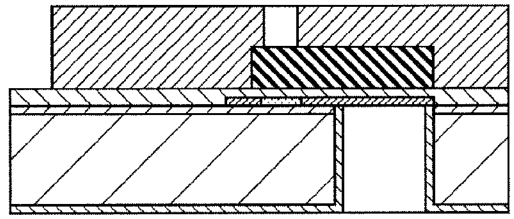


FIG. 15H

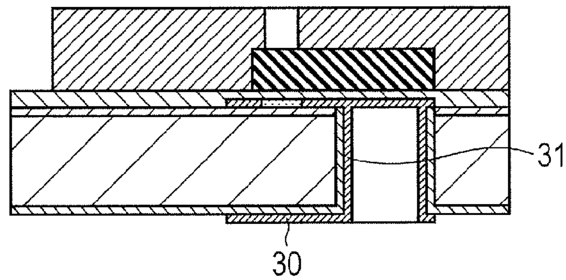


FIG. 15I

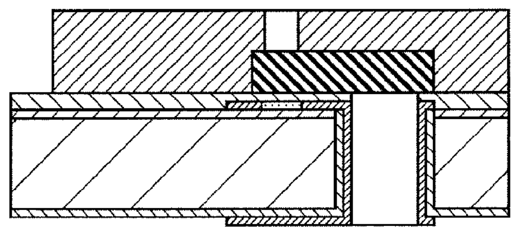


FIG. 15J

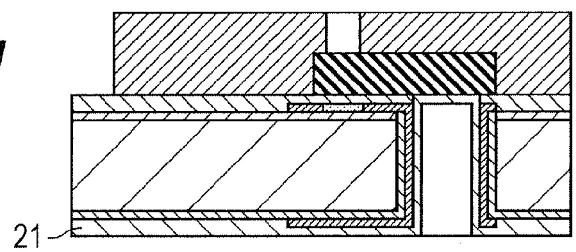


FIG. 15K

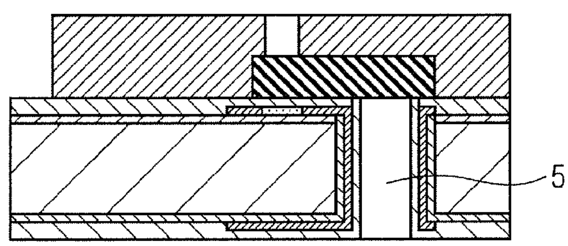
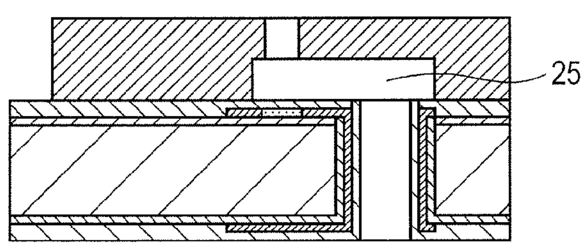


FIG. 15L



LIQUID EJECTION HEAD BODY AND METHOD OF MANUFACTURING THE SAME

TECHNICAL FIELD

This invention relates to a body (or a main part) of a liquid ejection head for ejecting liquid and a method of manufacturing the same.

BACKGROUND ART

Three-dimensional packaging technologies have been proposed in recent years in order to meet the demand for downsized electronic devices and devices having a raised mounting density. With the proposed three-dimensional packaging technologies, an electrode is formed so as to run through a substrate on which a semiconductor device is formed (i.e. a so-called through-electrode). With such technologies, the mounting density of devices is raised to downsize the final product not by arranging a plurality of semiconductor devices on a planar mounting surface but by vertically laying devices one on the other by way of a through-electrode.

In the case of forming an inkjet head body, on the other hand, as a result of formation of a through-electrode, an ink ejecting element of the head can be electrically connected thereto from the rear surface side of a substrate that is the side opposite to the direction of ink ejection. This technique provides advantages including an advantage of providing a capability of manufacturing a long recording head where a plurality of recording substrates are arranged side by side.

Known patent literature that proposes three-dimensional packaging technologies for inkjet head body includes PTL 1 listed below.

CITATION LIST

Patent Literature

PTL 1: Japanese Patent Application Laid-Open No. 11-192705

SUMMARY OF INVENTION

Technical Problem

As described above, the mounting density of a liquid ejection head body can be raised and the final product can be downsized by means of a three-dimensional packaging technology. However, liquid ejection head bodies are facing needs of realizing a higher mounting density and further downsizing.

Therefore, the object of the present invention is to provide a liquid ejection head body adapted for realizing a higher mounting density and further downsizing.

Solution to Problem

According to the present invention, the above object is achieved by providing a liquid ejection head body including a substrate and a channel forming member arranged on the substrate, the channel forming member having a liquid ejection port for ejecting liquid and a liquid channel communicating with the liquid ejection port, the substrate having an ejection energy generating element for generating energy for ejecting liquid on a first surface side thereof where the channel forming member is arranged and a liquid supply port running through the substrate from a second surface side opposite to the first surface side to the first surface side to supply liquid to the liquid channel, wherein a conductive layer for electrically connecting the first surface side and the second surface side is arranged along the lateral surface of the liquid supply port.

Thus, according to the present invention, there is provided a liquid ejection head body adapted to realizing a higher mounting density and further downsizing for the final product.

Further features of the present invention will become apparent from the following description of exemplary embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a schematic perspective view of an embodiment of inkjet head body according to the present invention, illustrating an exemplar configuration thereof (individual supply port type).

FIG. **2** is a schematic perspective view of an embodiment of inkjet head body according to the present invention, illustrating an exemplar configuration thereof (common supply port type).

FIG. **3** is a schematic cross-sectional view of an embodiment of inkjet head body according to the present invention held to a mounted position (individual supply port type).

FIG. **4** is a schematic cross-sectional view of an embodiment of inkjet head body according to the present invention held to a mounted position (common supply port type).

FIG. **5** is a schematic top plan view of a substrate, illustrating an exemplar wiring arrangement of an embodiment of inkjet head body according to the present invention (individual supply port type).

FIG. **6** is a schematic top plan view of a substrate, illustrating an exemplar wiring arrangement of an embodiment of inkjet head body according to the present invention (individual supply port type).

FIG. **7** is a schematic top plan view of the substrate, illustrating an alternative exemplar wiring arrangement of the embodiment of inkjet head body of FIG. **6** (individual supply port type).

FIG. **8** is a schematic top plan view of a substrate, illustrating an exemplar wiring arrangement of an embodiment of inkjet head body according to the present invention (common supply port type).

FIG. **9** is a schematic top plan view of a substrate, illustrating an exemplar wiring arrangement of an embodiment of inkjet head body according to the present invention (common supply port type).

FIG. **10** is a schematic top plan view of a substrate, illustrating an exemplar wiring arrangement of an embodiment of inkjet head body according to the present invention (common supply port type).

FIG. **11** is a schematic top plan view of a substrate, illustrating an exemplar wiring arrangement of an embodiment of inkjet head body according to the present invention (individual supply port type).

FIGS. **12**A, **12**B, **12**C, **12**D, **12**E, **12**F, **12**G, **12**H, and **12**I are schematic cross-sectional views of an embodiment of inkjet head body according to the present invention, illustrating the method of manufacturing the embodiment (individual supply port type).

FIGS. **13**A, **13**B, **13**C, **13**D, **13**E, **13**F, **13**G, **13**H, and **13**I are schematic cross-sectional views of an embodiment of inkjet head body according to the present invention, illustrating the method of manufacturing the embodiment (common supply port type).

FIGS. **14**A, **14**B, **14**C, and **14**D are schematic views of an embodiment of inkjet head body according to the present invention that corresponds to the embodiment of FIG. **10**, illustrating a configuration thereof (common supply port type).

FIGS. **15**A, **15**B, **15**C, **15**D, **15**E, **15**F, **15**G, **15**H, **15**I, **15**J, **15**K, and **15**L are schematic cross-sectional views of an embodiment of inkjet head body according to the present invention, illustrating the method of manufacturing the embodiment (individual supply port type).

DESCRIPTION OF EMBODIMENTS

The present invention relates to a liquid ejection head body. A liquid ejection head body according to the present invention includes a channel forming member and a substrate. The channel forming member has a liquid ejection port for ejecting liquid and a liquid channel communicating with the liquid ejection port. The substrate has an ejection energy generating element for generating energy for ejecting liquid on a first surface side thereof where the channel forming member is arranged and a liquid supply port running through the substrate from the opposite side (a second surface side) to the first surface side to supply liquid to the liquid channel. According to the present invention, a conductive layer for electrically connecting the first surface side and the second surface side is arranged along the lateral surface of the liquid supply port.

According to the prior art, a through-electrode is formed to electrically connect the front surface side and the rear surface side of a substrate and a through-hole running through the substrate needs to be formed in addition to a through-hole that operates as ink supply port.

According to the present invention, on the other hand, a conductive layer is formed along the lateral surface of a liquid supply port and hence an additional through-hole for a through-electrode does not need to be formed. As a result, the degree of freedom of wiring is improved.

Particularly, since the ejection energy generating element and the liquid supply port are formed in areas located close to each other, the conductive layer of the liquid supply port can be utilized as wiring for the ejection energy generating element to consequently improve the degree of freedom of the layout of the substrate so as to allow further downsizing.

In this specification, the present invention is mainly described in terms of inkjet head body, which is an exemplar application of the present invention. However, the present invention is by no means limited thereto and equally applicable to liquid ejection head bodies to be used e.g. for preparation of biochips and electronic circuit printing. Incidentally, the present invention is also applicable to liquid ejection head bodies for manufacturing color filters.

Embodiment 1

FIGS. **1** and **2** are schematic perspective views of embodiments of inkjet head body according to the present invention. FIGS. **3** and **4** are schematic cross-sectional views of embodiments of inkjet head body according to the present invention held to respective mounted positions. Note that the cross-sectional views of FIGS. **3** and **4** exactly correspond to the respective cross section parts of FIGS. **1** and **2**. FIGS. **1** and **3** illustrate an embodiment having an individual liquid supply port type arrangement (individual ink supply port type arrangement) as liquid supply port arrangement, whereas FIGS. **2** and **4** illustrate an embodiment having a common liquid supply port type arrangement (common ink supply port type arrangement) as liquid supply port arrangement. Note that both individual ink supply ports and common ink supply ports are denoted by the same reference symbols because they provide exactly the same effects regardless of the difference in the form of ink supply port.

Now, an embodiment of the present invention will be described below by referring to FIGS. **1** and **3**.

FIG. **1** illustrates an inkjet head body including a substrate **2** and a channel forming member **3** formed on the substrate **2** with an ink ejection port **4** facing upward. In FIG. **1**, the channel forming member **3** is provided to produce an ink ejection port **4** and an ink channel **25** communicating with the ink ejection port **4**. An ejection energy generating element **1** such as a heater is formed on the substrate **2**. The substrate **2** is typically a silicon substrate through which an ink supply port **5** communicating with the front surface (first surface) side and the rear surface (second surface) side of the substrate **2** is formed. Ink is ejected from the ink ejection port **4** by the energy generated from the ejection energy generating element **1** and, at the same time, ink is supplied from the ink supply port **5** to the ink channel **25**. The ejected ink hits a recording medium for a printing operation.

A conductive layer **31** is formed on the lateral wall of the ink supply port **5** that is formed as a through-hole in the substrate **2** so as to electrically connect the front surface side and the rear surface side of the substrate. More specifically, the conductive layer **31** is connected to a front surface wiring layer **32** arranged at the front surface side of the substrate **2** and also to a rear surface wiring layer **30** arranged at the rear surface side of the substrate **2**. While the conductive layer **31** is formed on the entire surface of the lateral wall of the through-hole formed in the substrate **2** in FIG. **1**, the conductive layer **31** may be formed in some other way provided that the conductive layer **31** electrically connects the front surface side and the rear surface side of the substrate. For example, the conductive layer **31** may be divided into a plurality of regions, each of which functions as wiring.

In FIG. **1**, the conductive layer **31** is arranged on the inner wall of the through-hole of the substrate and functions as through-electrode wiring. The conductive layer **31** is covered by a protective film **21** in order to prevent the conductive layer **31** from contacting ink.

Any material can be used for the conductive layer **31** so long as the material is electrically conductive. For example, a material that can be used for electric wiring may be used as the material of the conductive layer **31**.

Any material can be used for the protective film **21** so long as the material is resistant against liquid including ink and electrically insulating. Examples of materials that can be used for the protective film **21** include organic materials such as polyparaxylylene, polyparaxylene derivatives including polymonochloroparaxylylene, polydichloroparaxylylene and polytetrafluoroparaxylylene, polyurea resin and polyimide resin and inorganic materials such as silicon oxide and silicon nitride.

As illustrated in FIG. **1**, the protective film **21** may also be arranged on the rear surface (second surface) of the substrate **2**. If such is the case, the protective film **21** is preferably so arranged as to cover the rear surface wiring layer **30** that is arranged on the rear surface of the substrate **2** as illustrated in FIG. **1**.

As illustrated in FIG. **1**, a substrate protective film **12** may be arranged at the front surface side of the substrate **2** in order to protect the ejection energy generating element **1**, the front surface wiring layer **32**, the drive circuit **20** and so on.

A pair of electrodes is connected to the ejection energy generating element **1**, which may be a heater. One of the electrodes operates as power wiring while the other electrode operates as grounding wiring. Electric power to be supplied to the ejection energy generating element **1** is firstly supplied from the power wiring by way of the pair of electrodes arranged at the opposite sides of the element. In the case of the embodiment illustrated in FIG. **3**, electric power is supplied from a ceramic substrate conductive layer **41** arranged on a ceramic substrate **42** and led to the inside of inkjet body by way of a bump **6** connected to the conductive layer **41**. Then, in the inkjet body, power is supplied from the rear surface wiring layer **30**, which is connected to the bump **6**, to the conductive layer **31**. Then, power is supplied from the conductive layer **31** that functions as through-electrode wiring to the front surface wiring layer **32** and further from the front surface wiring layer **32** to the ejection energy generating element **1**. Note that the front surface wiring layer **32** may form part of the ejection energy generating element.

FIG. **3** illustrates a mode of realizing the present invention in which an inkjet head body as illustrated in FIG. **1** is mounted on a mounting base. Referring to FIG. **3**, the mounting base is formed mainly by the ceramic substrate **42**. An ink introducing port **45** is arranged in the ceramic substrate **42** and the inkjet head body is mounted in such a way that the ink introducing port **45** communicates with the ink supply port **5**. On the lateral surface of the ink introducing port **45**, a ceramic substrate protective film **43** is provided. A ceramic substrate conductive layer **41** is arranged under the ceramic substrate protective film **43**. The ceramic substrate conductive layer **41** is also arranged at the front surface side of the ceramic substrate **42**. The ceramic substrate conductive layer **41** and the rear surface wiring layer **30** are electrically connected to each other by way of the bump **6**. A sealing member **44** is arranged between the mounting base and the inkjet head body to establish a tight sealing effect.

As a conductive layer is arranged on the lateral surface of the liquid supply port according to the present invention, there is no need of arranging an additional through-hole that runs through the substrate beside the liquid supply port. Then, as a result, the liquid ejection head body can be downsized.

Furthermore, since the liquid supply port is arranged close to the ejection energy generating element, the parasitic resistance of wiring that arises when driving the ejection energy generating element can be reduced to improve the energy efficiency by utilizing the conductive layer arranged on the lateral surface of the liquid supply port.

Besides, a large perimeter or area and a large wiring width can be provided for the conductive layer by arranging the conductive layer on the entire surface of the lateral wall of the liquid supply port so as to entirely surround the latter. Then, the parasitic resistance of wiring can be further reduced to additionally improve the energy efficiency.

Embodiment 2

FIGS. **12**A through **12**I are schematic cross-sectional views of an embodiment of inkjet head body according to the present invention, illustrating the method of manufacturing the embodiment. This embodiment will now be described below by referring to FIGS. **12**A through **12**I.

Firstly, as illustrated in FIG. **12**A, a silicon substrate **2** on which a semiconductor element (not illustrated) or ejection energy generating element **1** is formed is brought in.

Such a semiconductor element or an ejection energy generating element **1** can be formed by means of a multilayer wiring technique typically using photolithography.

The ejection energy generating element **1** is formed at the front surface side (first surface side) of the silicon substrate **2**. A front surface wiring layer **32** that is connected to the ejection energy generating element **1** is formed on the front surface side of the silicon substrate **2**. A substrate protective film **12** is formed on the ejection energy generating element **1** and the front surface wiring layer **32**.

Then, as illustrated in FIG. **12**B, an ink channel pattern **24** is formed as mold member for an ink channel.

The ink channel pattern **24** operates as a mold member for forming an ink channel **25** and is removed in a later step. Therefore, the material of the ink channel pattern is preferably selected on an assumption that a process of removing the ink channel pattern will be executed later. For example, positive type resist can be employed as the material of the ink channel pattern **24**.

Then, as illustrated in FIG. **12**C, a channel forming member **3** is formed on the ink channel pattern **24**.

For example, negative type resist can be employed as the material of the channel forming member **3**.

Then, as illustrated in FIG. **12**D, an ink ejection port **4** is formed in the channel forming member **3** by photolithography.

Subsequently, as illustrated in FIG. **12**E, the silicon substrate **2** is etched from the rear surface side (second surface side) all the way to the front surface side to form through-hole **5***a*.

A Deep-RIE technique or an anisotropic etching technique can be used for the above etching operation. Anisotropic etching may be reactive ion etching (RIE) or anisotropic crystal etching. Deep-RIE is preferably employed as RIE. A Bosch process can be employed for Deep-RIE.

Then, as illustrated FIG. **12**F, a conductive layer **31** is formed on the lateral wall of the through-hole. At this time, rear surface wiring layer **30** can also be formed by arranging a conductive material on the rear surface of the silicon substrate **2**.

The conductive layer **31** is desirably formed from the rear surface side of the silicon substrate **2**. The conductive layer **31** is formed so as to be electrically connected to the front surface wiring layer **32** that is arranged at the front surface side of the silicon substrate **2**. The front surface wiring layer **32** may be multilayer wiring.

The conductive layer **31** can be formed, for example, by means of plating, CVD, sputtering, or evaporation.

Then, as illustrated in FIG. **12**G, a protective film **21** that provides an excellent coverage effect is formed on the conductive layer **31** in order to secure a sufficient degree of resistance against ink for the ink supply port. At this time, the protective film **21** can be formed at the rear surface side of the silicon substrate **2** at the same time to cover the rear surface wiring layer **30**.

Then, as illustrated in FIG. **12**H, the protective film **21** on the bottom surface part of the through-hole is removed to produce ink supply port **5**. Note that the lateral wall of the ink supply port is covered by the protective film **21**.

Techniques that can be used to remove the protective film **21** include laser techniques and RIE.

At this time, the part of the protective film **21** at the rear surface side of the silicon substrate **2** that corresponds to external input/output electrodes can be partly removed at the same time.

Then, as illustrated in FIG. **12**I, the ink channel pattern **24** is dissolved and removed to produce the ink channel **25**.

The process of manufacturing an inkjet head body is completed when the above steps are over.

In this embodiment, an insulating film can be arranged between the silicon substrate **2** and the conductive layer **31** or between the silicon substrate **2** and the rear surface wiring layer **30**. Additionally, an insulating film can be arranged between the silicon substrate **2** and the front surface wiring layer **32** or between the silicon substrate **2** and the substrate protective film **12**. These insulating films can be formed by using the same material as that of the protective film **21**.

While the manufacturing method of this embodiment is based on a method that is generally referred to as "casting method", the present invention is by no means limited thereto.

Now, the mounting base will be described below by referring to FIG. **3**.

The obtained inkjet head body is cut out from the wafer by dicing and then bonded to and mounted on a mounting base that operates as head substrate by means of the bump **6**.

The mounting base is mainly formed by a ceramic substrate **42** and an ink introducing port **45** is formed in the ceramic substrate **42**. A ceramic substrate conductive layer **41** is formed on the lateral surface of the ink introducing port **45** of the ceramic substrate **42** and covered by a ceramic substrate protective film **43**.

The ceramic substrate conductive layer **41** is so formed as to extend to the surface of the ceramic substrate **42** and electrically connected to the rear surface wiring layer **30** of the inkjet head body by means of the bump **6**. The connecting section is sealed by sealing member **44** that is made of a resin material.

The ceramic substrate protective film **43** can be formed from the rear surface side of the ceramic substrate **42** after mounting the inkjet head body.

Embodiment 3

Different wiring arrangements arise for ejection energy generating elements depending on if there is a drive circuit arranged on the substrate front surface or not. For the purpose of the present invention, a drive circuit refers to an integrated circuit for switching operations for driving an ejection energy generating element. Such a drive circuit can be formed in a substrate by means of a semiconductor element.

When a drive circuit is formed in a substrate, an arrangement of connecting the wiring of one of a pair of electrodes for driving the ejection energy generating element to the drive circuit and connecting the wiring of the other electrode to the conductive layer may be employed.

If, for example, no drive circuit is arranged on the front surface side of the substrate, both the power wiring and the grounding wiring can be taken out to the rear surface side of the substrate by way of the conductive layer **31** arranged on the lateral surface of the ink supply port **5** that functions as through-electrode wiring.

FIG. **5** is a schematic top plan view of a substrate, illustrating an exemplar arrangement of an embodiment of inkjet head body according to the present invention. This embodiment will be described below in detail. In FIG. **5**, individual ink supply ports **5** are provided and an ejection energy generating element **1** (e.g., heater element) is connected to front surface wiring layer **32**. The front surface wiring layer **32** includes a pair of electrodes of the ejection energy generating element and one of the electrodes operates as power wiring while the other electrode operates as grounding wiring. In the mode of realizing the present invention illustrated in FIG. **5**, both the power wiring and the grounding wiring of the ejection energy generating element are electrically connected to the rear surface side of the substrate by way of the conductive layer **31** arranged on the lateral surface of the ink supply port **5**. In other words, power is supplied to the power wiring from the rear surface side of the substrate by way of the conductive layer **31** and the grounding wiring is grounded at the rear surface side of the substrate by way of the conductive layer **31**.

The embodiment illustrated in FIG. **5** is effective when an individual ink supply port type arrangement is provided.

In the case of an embodiment having an individual ink supply port type arrangement, for example, a plurality of individual ink supply ports can be arranged in a row along a plurality of ejection energy generating elements. One or more individual ink supply ports may be held in communication with a single ejection energy generating element. Alternatively, one or more individual ink supply ports may be held in communication with a plurality of ejection energy generating elements. For example, two rows of ink ejection ports may be provided at the respective opposite sides of a row of individual ink supply ports.

Embodiment 4

When a drive circuit is arranged at the front surface side of a substrate, either one **32** of the power wiring and the grounding wiring can be taken out from the rear surface side of the substrate by way of the conductive layer **31** arranged on the lateral surface of the ink supply port **5** that functions as through-electrode wiring.

FIG. **6** is a schematic top plan view of a substrate, illustrating an exemplar arrangement of an embodiment of inkjet head body according to the present invention. This embodiment will be described below in detail. In this embodiment, a drive circuit **20** is formed on the front surface side of a substrate. The drive circuit **20** may typically be formed by a transistor that operates as switch and a signal line for driving the transistor. The embodiment illustrated in FIG. **6** has an individual ink supply port type arrangement as ink supply port arrangement and either the power wiring or the grounding wiring of each ejection energy generating element is electrically connected to the rear surface side of the substrate by way of the conductive layer **31**, while the other wiring is electrically connected to the drive circuit **20**.

Since through-electrode wiring is arranged on the lateral surface of each ink supply port of this embodiment, this embodiment provides a higher degree of freedom of layout for the drive circuit **20**. Accordingly, the substrate of the embodiment can be downsized.

FIG. **7** illustrates an alternative exemplar wiring arrangement of this embodiment. The arrangement of FIG. **7** differs from that of FIG. **6** in the direction of leading out the electrodes of each of the ejection energy generating elements. With the arrangement of FIG. **7**, both the power wiring and the grounding wiring of each of the ejection energy generating elements are arranged linearly. This arrangement provides an advantage of reducing the parasitic resistance of wiring.

Embodiment 5

The embodiment illustrated in FIGS. **8** and **9** has a common ink supply port type arrangement and a drive circuit **20** is formed on the front surface side of the substrate of the embodiment. The opening of the common ink supply port is rectangular in shape. The lateral wall of the common ink supply port **5** is typically inclined relative to the surface direction of the substrate.

In the embodiment illustrated in FIG. **8**, either one **32** of the power wiring and the grounding wiring of the ejection energy generating element is electrically connected to the rear surface side of the substrate by way of a conductive layer **31** and the other one is connected to the drive circuit **20**. The wirings connected to the conductive layer **31** are put together as single common wiring arrangement.

In this embodiment, the wiring connected to the conductive layer **31** is preferably the power wiring. As the power wirings of the ejection energy generating element are put together as single common wiring arrangement, the power wiring can be made to have a large width to reduce the parasitic resistance of the power wiring.

In the embodiment illustrated in FIG. **9**, the conductive layer **31** is divided into a plurality of regions and functions as plural wiring arrangement for electrically connecting the front surface side and the rear surface side of the substrate.

In this embodiment, the wiring connected to the conductive layer **31** is preferably the power wiring. In FIG. **9**, the conductive layer is divided into a plurality of regions, which preferably form individual wirings that respectively correspond to the plurality of power wirings. In this embodiment, the plural power wirings can be individually connected to the rear surface side of the substrate.

Embodiment 6

The embodiment illustrated in FIG. **10** has a common ink supply port type arrangement and the power wiring and the grounding wiring are connected to the rear surface side of the substrate by way of a conductive layer **31**. The conductive layer **31** is divided into a plurality of regions, which function as plural wirings for electrically connecting the front surface side and the rear surface side of the substrate.

This embodiment will be described in greater detail by referring to FIGS. **14**A through **14**D. FIGS. **14**A through **14**D are orthographic views of the segment of the inkjet head body of this embodiment, illustrating the configuration of the substrate thereof. FIGS. **14**A and **14**D are schematic plan views of the front surface and the rear surface of the substrate. FIG. **14**B is a schematic partial cross-sectional view taken along line **14**B-**14**B in FIG. **14**A and FIG. **14**C is a schematic cross-sectional view taken along line **14**C-**14**C in FIG. **14**A (and FIG. **14**D).

Embodiment 7

FIG. **11** is a schematic top plan view of a substrate, illustrating an exemplar arrangement of an embodiment of inkjet head body according to the present invention. The embodiment of FIG. **11** has an individual ink supply port type arrangement and no drive circuit is formed on the front surface of the substrate thereof. The power wiring and the grounding wiring **32** of each of the ejection energy generating elements are electrically connected to the rear surface side of the substrate by way of a conductive layer **31** arranged on the lateral surface of an ink supply port **5**. In short, electric power is supplied to the power wiring from the rear surface side of the substrate by way of the conductive layer **31**. The grounding wiring is grounded at the rear surface side of the substrate by way of the conductive layer **31**.

In this embodiment, individual ink supply ports **5** are arranged in two rows at the opposite sides of the ejection energy generating elements that are arranged in a row. Two ink supply ports **5** are provided for a single ejection energy generating element.

This embodiment does not require any row of through-electrodes at the outside of ink supply ports **5** arranged in two rows, for example. Additionally, the power wiring and the grounding wiring of each of the ejection energy generating elements that are linearly connected are not required to make a detour so as to be connected to the through-electrode. Thus, this arrangement is effective for reducing the parasitic resistance of the power wiring and the grounding wiring.

Example 1

An instance of manufacturing an inkjet head body by means of the method illustrated in FIGS. **12**A through **12**I will be described for this example.

Firstly, as illustrated in FIG. **12**A, a 200 μm-thick silicon substrate was brought in as substrate **2**. A heater that operates as ejection energy generating element **1** was formed on the silicon substrate. A 0.5 μm-thick metal thin film, or aluminum thin film, was formed and a heater electrode (wiring) was formed out of the aluminum thin film as front surface wiring layer **32**. Then, a 0.5 μm-thick silicon oxide film that was to operate as substrate protective film **12** (the uppermost protective film of multi-wiring layers) was formed at the front surface side of the silicon substrate by means of plasma CVD.

Then, as illustrated in FIG. **12**B, an ink channel pattern **24** that was to operate as mold member was formed. More specifically, the ink channel pattern **24** was formed firstly by spin coating polymethylisopropylketone (ODUR-1010: tradename, available from TOKYO OHKA KOGYO CO., LTD), which is a dissolvable resin material, and then by patterning the resin material by way of exposure and development steps.

Thereafter, as illustrated in FIGS. **12**C and **12**D, a channel forming member **3** was formed by spin coating cationic polymerization type epoxy resin and then an ink ejection port **4** was formed by way of exposure and development steps.

Then, as illustrated in FIG. **12**E, the silicon substrate was etched from the rear surface side to form a through-hole **5*a***. A mixture gas of SF_6 and C_4F_6 was employed as etching gas. The Deep-RIE technique of alternately conducting etching steps and film forming steps was employed as etching technique. The through-hole **5*a*** was open both at the front surface and at the rear surface of the silicon substrate and also formed through the substrate protective film **12**.

Then, as illustrated in FIG. **12**F, a conductive layer **31** was formed by means of gold plating. The conductive layer **31** was electrically connected to the metal thin film of aluminum that was formed on the front surface of the silicon substrate so as to operate as heater electrode (wiring). Additionally, a conductive layer **31** was formed on the lateral wall of the through-hole **5*a*** and, at the same time, a rear surface wiring layer **30** was formed on the rear surface of the silicon substrate.

Thereafter, as illustrated in FIG. **12**G, a 2 μm-thick protective layer **21** was formed on the conductive layer **31** and also on the rear surface of the silicon substrate by means of polyparaxylylene resin and organic CVD.

Organic CVD film can achieve high covering power and realize an excellent coverage performance at an ink supply port representing a high aspect ratio (e.g., substrate thickness: 200 μm, pore aperture: □50 μm).

Then, as illustrated in FIG. **12**H, the protective film **21** of resin at the bottom surface section of the through-hole was removed to produce an ink supply port. This step was executed by means of a laser. In this example, the protective film at the bottom surface section of the ink supply port **5** was partly removed by means of an excimer laser that is an UV pulse laser (wavelength: 248 nm, pulse width: 30 ns, energy density: 0.6 J/cm2). At this time, the film thickness of the protective layer **21** was 2 μm and the resin film was partly removed by a desired thickness by way of a number of shots of irradiation of laser beam. Also at this time, the part of the protective film **21** at the rear surface side of the silicon substrate that was to be turned into external input/output electrodes was also partly removed.

Subsequently, as illustrated in FIG. **12**I, the ink channel pattern **24** was dissolved and removed by means of photoresist remover solution that contained methyl lactate to produce an ink channel **25**.

An inkjet head body was prepared by way of the above-described steps.

The method of this example was able to eliminate an etching step exclusively for forming a through-electrode that is indispensable for the prior art. As a result, the number of steps for manufacturing a liquid ejection head body can be reduced.

Additionally, the method of this example can form a rear surface wiring layer **30** on the rear surface of a substrate and a conductive layer **31** simultaneously. Then, the operation of masking the ink supply port or the through-electrode that is indispensable for the prior art can also be eliminated to further reduce the number of steps for manufacturing a liquid ejection head body.

Example 2

FIGS. **13**A through **13**I are schematic cross-sectional views of an embodiment of inkjet head body according to the present invention, illustrating the method of manufacturing the embodiment. In this example, a through-hole is formed in a substrate by means of anisotropic crystal etching.

The steps of the method of this example are the same as those of Example 1 except the step of forming through-hole **5***a*. Now, the step of forming a through-hole **5***a* will be described below.

As illustrated in FIG. **13**E, the silicon substrate was etched from the rear surface side to produce a through-hole **5***a*. TMAH, that is an alkali solution, and anisotropic crystal etching were employed for the etching operation. The silicon substrate had crystal orientation of wafer surface direction <100> and hence the operation of anisotropic crystal etching proceeded at an angle so that the lateral wall of the through-hole **5***a* was formed with a certain angle of inclination from the rear surface to the front surface of the substrate. Note that the plane direction of the lateral wall of the through-hole **5***a* was <111>.

Example 3

The method of manufacturing an inkjet head body as illustrated in FIG. **14** was employed for this example.

The manufacturing method of this example is the same as the above-described method of Example 2 except that the method of this example has an additional step. Hence, only the added step will be described below and the remaining step will not be described repeatedly.

More specifically, the steps in FIGS. **13**A through **13**F, or the steps down to the step of forming a conductive layer **31** are the same as those of Example 2.

In this example, a patterning operation was conducted on the conductive layer **31** that was gold plating film formed in the through-hole **5***a* to produce a plurality of wirings as illustrated in FIGS. **14**A through **14**D. The operation of patterning the conductive layer was conducted from the rear surface of the substrate by way of a laser process.

All the following steps are the same as those illustrated in FIGS. **13**G through **13**I.

With the method of this example, a conductive layer that operates as a wiring arrangement of a plurality of through-electrode wirings can be formed by wiring patterning at a common ink supply port.

Example 4

FIGS. **15**A through **15**I are schematic cross-sectional views of an embodiment of inkjet head body according to the present invention, illustrating the method of manufacturing the embodiment. Now, an instance of manufacturing an inkjet head body will be described below by referring to FIGS. **15**A through **15**I.

In this example, a substrate front surface insulating film **13**, a substrate rear surface insulating film **22** and a substrate supply port insulating film **33** were arranged respectively between the substrate **2** and the front surface wiring layer **32** that may typically be a heater electrode for the substrate front surface, between the substrate **2** and the rear surface wiring layer **30** and between the substrate **2** and the conductive layer **31**. In short, an insulating film was formed between the wiring and the substrate.

Firstly, as illustrated in FIG. **15**A, a 200 μm-thick silicon substrate was brought in as substrate **2**. Then, a 0.5 μm-thick silicon oxide film that was to operate as substrate front surface insulating film **13** was formed by means of low pressure CVD. For this operation, the part where an ink supply port **5** was to be formed in a later step was subjected to a masking operation in advance so that no silicon oxide film might be formed there. Then, a heater that was to operate as ejection energy generating element **1** was formed on the substrate front surface insulating film **13**. Additionally, a heater electrode (wiring) was formed as front surface wiring layer **32** by forming a 0.5 μm-thick metal thin film of aluminum. Then, a 0.5 μm-thick silicon oxide film that was to become substrate protective film **12** (the uppermost protective film of multi-wiring layers) was formed at the front surface side of the silicon substrate by means of plasma CVD.

Subsequently, an ink channel pattern **24** was formed as illustrated in FIG. **15**B. The ink channel pattern **24** was formed firstly by spin coating polymethylisopropylketone (ODUR-1010: tradename, available from TOKYO OHKA KOGYO CO., LTD), which is a dissolvable resin material, and then by patterning the resin material by way of exposure and development steps.

Thereafter, as illustrated in FIGS. **15**C and **15**D, a channel forming member **3** was formed by spin coating cationic polymerization type epoxy resin and then ink ejection port **4** was formed by way of exposure and development steps.

Then, as illustrated in FIG. **15**E, the silicon substrate was etched from the rear surface side to form a through-hole **5***a*. A mixture gas of SF_6 and C_4F_6 was employed as etching gas. The Deep-RIE technique of alternately conducting etching steps and film forming steps was employed as etching technique. The etching operation was stopped at the heater electrode (wiring) **32**. The through-hole **5***a* was running through the silicon substrate.

Subsequently, as illustrated in FIG. **15**F, a 2 μm-thick poly-paraxylylene resin film was arranged in the through-hole **5***a* and on the rear surface of the silicon substrate by means of organic CVD to form a substrate rear surface insulating film **22** and a substrate supply port insulating film **33**.

Then, as illustrated in FIG. **15**G, the substrate rear surface insulating film **22** at the bottom surface section of the through-hole **5***a* was partly removed. This step was executed by means of laser hole drilling. In this example, a through-hole of about □50 μm was formed by means of an excimer laser that is an UV pulse laser (wavelength: 248 nm, pulse width: 30 ns, energy density: 0.6 J/cm2).

Thereafter, as illustrated in FIG. **15**H, a conductive layer **31** was formed by means of gold plating. Additionally, a conductive material was also arranged at the rear surface side of the silicon substrate to form a rear surface wiring layer **30**. The conductive layer **31** was electrically connected to the metal thin film of aluminum that was formed on the front surface of the silicon substrate so as to operate as heater electrode (wiring) **32**.

Then, as illustrated in FIG. **15**I, the heater electrode (wiring) **32** and the conductive layer **31** at the bottom surface section of the through-hole **5***a* were partly removed by means of a laser. In the laser hole drilling operation, not only the metal film but also the substrate protective film **12** at the bottom surface section of the through-hole **5***a* were removed.

Subsequently, as illustrated in FIGS. **15**J and **15**K, a 2 μm-thick polyparaxylylene resin film was formed on the conductive layer **31** and also on the rear surface side of the silicon substrate to produce a protective film **21** by means of organic CVD. Then, the protective film **21** at the bottom surface section of the through-hole was partly removed by means of a laser to produce an ink supply port.

The technique employed to form and partly remove the substrate rear surface insulating film **22** and the substrate supply port insulating film **33** could also be employed to form and partly remove the protective film **21**.

Then, as illustrated in FIG. **15**L, the ink channel pattern **24** was dissolved and removed by means of photoresist remover solution that contained methyl lactate to produce an ink channel **25**.

An inkjet head body was prepared by way of the above-described steps.

The embodiment described in this example was provided with substrate front surface insulating film **13**, substrate rear surface insulating film **22** and substrate supply port insulating film **33**. Additionally, an excellent coverage effect can be realized by forming the substrate rear surface insulating film **22** and the substrate supply port insulating film **33** by means of the same material as the protective film **21** for producing organic CVD film. Thus, conductive layer **31** of the inkjet head body of this embodiment is covered by protective film that provides an excellent coverage effect to obtain an excellent ink-resistant property.

While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

This application claims the benefit of Japanese Patent Application No. 2011-197143, filed Sep. 9, 2011, which is hereby incorporated by reference herein in its entirety.

The invention claimed is:

1. A liquid ejection head body comprising:

a substrate; and

a channel forming member arranged on the substrate,

the channel forming member having a liquid ejection port for ejecting liquid and a liquid channel communicating with the liquid ejection port, and

the substrate having an ejection energy generating element for generating energy for ejecting liquid on a first surface side thereof where the channel forming member is arranged and a liquid supply port running through the substrate from a second surface side opposite to the first surface side to the first surface side to supply the liquid to the liquid channel, wherein a conductive layer for electrically connecting the first surface side and the second surface side is arranged along a lateral surface of the liquid supply port.

2. The liquid ejection head body according to claim **1**, wherein

the surface of the conductive layer is covered by a protective film that prevents the conductive layer and the liquid from contacting each other.

3. The liquid ejection head body according to claim **1**, wherein

the ejection energy generating element is electrically connected to the second surface side of the substrate by way of the conductive layer.

4. The liquid ejection head body according to claim **3**, wherein

the liquid supply port is comprised of a plurality of individual liquid supply ports.

5. The liquid ejection head body according to claim **4**, wherein:

a drive circuit is formed at the first surface side of the substrate; and

one of a pair of electrodes of the ejection energy generating element is connected to the drive circuit while the other is connected to the conductive layer.

6. The liquid ejection head body according to claim **4**, wherein

both of a pair of electrodes of the ejection energy generating element are connected to the conductive layer arranged in the individual liquid supply ports.

7. The liquid ejection head body according to claim **6**, wherein:

two individual liquid supply ports communicate with the ejection energy generating element;

one of the pair of electrodes of the ejection energy generating element is connected to the conductive layer arranged at one of the two individual liquid supply ports; and

the other of the pair of electrodes is connected to the conductive layer arranged at the other one of the two individual liquid supply ports.

8. The liquid ejection head body according to claim **3**, wherein

the liquid supply port is comprised of a common liquid supply port.

9. The liquid ejection head body according to claim **8**, wherein:

a drive circuit is formed at the first surface side of the substrate; and

one of the pair of electrodes for driving the ejection energy generating element is connected to the drive circuit while the other wiring is connected to the conductive layer.

10. The liquid ejection head body according to claim **8**, wherein

the conductive layer is comprised of a plurality of separate wires each electrically connecting the first surface side and the second surface side.

11. The liquid ejection head body according to claim **10**, wherein

the ejection energy generating element is comprised of a plurality of individual generating elements connected to the separate wires.

12. The liquid ejection head body according to claim **8**, wherein:

the conductive layer is comprised of a plurality of separate wires each electrically connecting the first surface side and the second surface side; and

both of the pair of electrodes of the ejection energy generating element are connected to each of the plurality of wires constituting the conductive layer.

13. The liquid ejection head body according to claim **1**, wherein an insulating film is arranged between the substrate and the conductive layer.

14. The liquid ejection head body according to claim **1**, wherein

the liquid ejection head body is an inkjet head body for ejecting ink as the liquid.

15. A method of manufacturing a liquid ejection head body comprising:

(1) a step of providing a substrate having an ejection energy generating element for generating energy for ejecting liquid and a surface wiring layer for driving the ejection energy generating element at a first surface side thereof;

(2) a step of etching the substrate from a second surface side disposed opposite to the first surface side to form a through-hole for liquid supply;

(3) a step of forming a conductive layer to be connected to the surface wiring layer on a lateral surface of the through-hole; and

(4) a step of forming a protective film on the conductive layer.

16. The method according to claim **15**, wherein

the substrate is a silicon substrate and the through-hole is formed by means of anisotropic crystal etching of the silicon substrate in the step (2).

17. The method according to claim **16**, wherein

a lateral wall representing a certain inclination is formed by the anisotropic crystal etching.

18. The method according to claim **17**, further comprising:

a step of patterning the conductive layer to produce a plurality of wirings connecting the first surface side and the second surface side between the step (3) and the step (4).

19. The method according to claim **15**, further comprising

a step of forming an insulating film on the lateral surface of the through-hole between the step (2) and the step (3), so as to form the conductive layer on the insulating film in Step (3).

20. The method according to claim **19**, wherein

the insulating film and the protective film are formed by the same resin material and organic CVD.

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